A Simple and Low-cost Mobile Sensor System for Measuring Spatial Concentration Gradient of PM$_{2.5}$

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Abstract

- Capturing spatial variations of air pollutant concentration are important for exposure assessment and air quality management purposes.
- Most research-grade mobile sampling instruments are large, expensive, and require vehicle modifications.
- Here we demonstrate a simple mobile sensor system based on low-cost optical particle sensors to characterize spatial concentration gradient of PM$_{2.5}$.
- The system is low-power consumption, small and can be easily attached to carrying vehicle without physical alternation to the vehicle.
- We tested the sensor along a fixed bus route and preliminary results suggest reasonable performance.

Mobile Sampling & Data Processing

- Sensor system attached to a UCF campus shuttle for a week (8/17/2018 – 8/24/2018)
- Shuttle drives between UCF campus and two off-campus apartments about 4 km away
- Sensor system and GPS powered through the 12V vehicle charging port using an USB adapter
- Configured to measure PM$_{1}$, PM$_{2.5}$, and PM$_{10}$ concentration every 5s
- Data stored on a internal microSD card.
  - ~119,000 data points collected during the week
  - 30 s GPS data interpolated to time stamp of PM data, and averaged to 100 m roadway segments

Low-cost sensor system

- Sensing units developed by Dr. Michael Bergin’ group at Duke University.
- Plantower PMS 3003 optical particle sensor
- 3D printed weather-proof enclosure with a 5 V, 30 mm fan for air exchange (Fig. 1 & 2)
- Location tracked using QStarz’s BT-Q1000XT GPS Travel Recorder at 30 s

Results and Discussion

- The highest PM$_{2.5}$ concentrations were found near the transit center, where shuttle idling activities are common
- At the two intersections near UCF main campus, PM$_{2.5}$ concentrations are consistently higher than elsewhere. Heavy vehicle volumes are expected at these two intersections.
- PM$_{2.5}$ concentrations near UCF campus are higher during morning rush hour (7-9 am), but not as high during afternoon rush hour.
- The captured spatial and temporal patterns of concentration variations are reasonable.
- This sensor system is low-cost (~$400), easy to deploy and operate, and can be expanded to also measure concentrations of selected gaseous pollutants.
- It’s suitable for the purpose of identifying pollution hotspot.
- This is a rather “hobbyist” style system with no accurate flow and turbulence control mechanisms. Careful calibration is needed.

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